



## Antistatic Polycarbonate/Copper Oxide Composite

Surface resistance lies in the desired range.

*Lyndon B. Johnson Space Center, Houston, Texas*

A composite material consisting of polycarbonate filled with copper oxide has been found to be suitable as an antistatic material. This material was developed to satisfy a requirement for an antistatic material that has a mass density less than that of aluminum and that exhibits an acceptably low level of outgassing in a vacuum.

Polycarbonate was chosen as the matrix material because it was known to satisfy the low-outgassing requirement. Copper oxide was chosen as the electrically conductive filler material in order to obtain surface resistivity in the desired static-electricity-dissipation range

between about  $10^5$  and  $10^{11}$  ohms per square. (Materials with lower surface resistivities are regarded as conductive; materials with surface resistivities greater than about  $10^{12}$  ohms per square are regarded as insulative and thus not suitable for protecting items sensitive to electrostatic discharge.)

A specimen of the copper oxide-filled carbonate material was subjected to a parallel-bar-contact surface-resistivity test and a static-discharge test at a temperature of 22 °C and relative humidity of 50 percent. The specimen was found to have a surface resistivity of  $10^9$

ohms per square on its rough side and  $10^{10}$  ohms per square on its smooth side. The time for discharging from a potential of 5,000 V to 500 V was measured to be about 0.1 s, and there was no measurable charge left after 5 s. These measured characteristics are well within the acceptable ranges for an antistatic material according to applicable NASA and military standards.

*This work was done by Michael Kovich of Lockheed Martin Corp. and George R. Rowland, Jr., of Hernandez Engineering Inc. for Johnson Space Center. Further information is contained in a TSP (see page 1). MSC-23356*

## Better VPS Fabrication of Crucibles and Furnace Cartridges

The choice of alloy composition and processing parameters is important.

*Marshall Space Flight Center, Alabama*

An experimental investigation has shown that by (1) vacuum plasma spraying (VPS) of suitable refractory metal alloys on graphite mandrels, and then (2) heat-treating the VPS alloy deposits under suitable conditions, it is possible to fabricate improved crucibles and furnace cartridges that could be used at maximum temperatures between 1,400 and 1,600 °C and that could withstand chemical attack by the materials to be heated in the crucibles and cartridges. Taken by itself, the basic concept of fabricating furnace cartridges by VPS of refractory materials onto graphite mandrels is not new; taken by itself, the basic concept of heat treatment of VPS deposits for use as other than furnace cartridges is also not new; however, prior to this investigation, experimental crucibles and furnace cartridges fabricated by VPS had not been heat treated and had been found to be relatively weak and brittle. Accordingly, the investigation was directed toward determining whether certain combinations of (1) refractory alloy compositions, (2) VPS parameters, and (3) heat-treatment parameters could result in VPS-

fabricated components with increased ductility.

The table describes five refractory metal alloys that were considered in this investigation. In each case, during vacuum plasma spraying, the alloy powder or corresponding mixture of elemental metal powders was delivered to a plasma gun by a flow of argon. The plasma gun was located in a vacuum chamber that

was evacuated and backfilled with argon at a low pressure. The plasma gun generated an argon/hydrogen plasma that melted the powder and projected it toward graphite mandrels, which were rotated so that the VPS deposits would form tubes. After plasma spraying, the tubes were removed from the mandrels.

Some of the VPS tubes were subjected to heat treatments based on current prac-

Alloy Composition, Weight Percentages	Supplied as Mixture of Elemental Powders (M) or as an Alloy Powder (A)
95.5 W, 3.5 Ni, 1.0 Fe	M
60 Mo, 40 Re	M
90 Ta, 10 W	M
75 W, 25 Re	M
99 Nb, 1 Zr	A

These Refractory Alloys were tested in experiments on fabrication by VPS and heat treatment.